AN9006 July 1990

Harris Semiconductor

HV-2405E OPERATION FROM FULL BRIDGE

(Reduces power dissipated in R1 by nearly 30%)

In applications where the heat dissipation in the source resistor R1 is a problem, a bridge rectifier circuit can be used to cut power dissipation by 29.3%

Other benefits of this circuit are:

1) The C2 capacitor can be half the value it was in the regular applications circuit due to double the frequency.
2) The R1 resistors can be physically smaller since they dissipate less power.
3) The small switching spike present on the regulated output is reduced due to the reduction in peak amplitude of the input current pulses. Also the frequency of the spikes is twice the line frequency.

The R1 resistor has a dual purpose. First and foremost it limits inrush current when the device is initially connected to the power source. This is necessary because the energy storage capacitor is totally discharged at that time and appears as a short circuit to ground. Thus, the only elements in the current path between AC Hot and AC Return are the source resistor (R1) and a "turned-on" SCR. When the C2 capacitor finishes charging the SCR must interrupt the current. Unfortunately, R1 must be sized to limit current during this inrush mode (unless other methods are employed to limit current). The second function of the R1 resistor is to limit surge currents from transients such as lightning strikes. A smaller value resistor would normally be acceptable for this purpose.

The equation for average power in R1 is $P_d = 1.33 \sqrt{\pi R_1 \, V_{PEAK}(I_{OUT})^3}$ using the standard applications circuit shown in the data sheet. With this circuit the HV-2405E/1205 turns on once during each line cycle. A large current flows into the C2 capacitor for a short period of time. Since power in R1 is related to the square of the input current, reducing this current (without increasing the ohmic value of R1 itself) would cause a decrease in dissipated power. It is worth noting that the HV-2405E can run with half the value of R1 as the HV-1205, so in 120V applications switching to the HV-2405E and cutting the resistor value in half will reduce power by 30%.

Operating the part from a full wave bridge rectifier is one way to reduce that peak current. The full bridge doubles the effective frequency of the input voltage without changing the rate of rise of that voltage. Consequently the recharging input current pulses into the HV-2405E/1205 occur twice as often so they are of lesser amplitude. The end result is a 30% reduction in P_d in R1. Graphs 1 and 2 show normal operation and operation from a full bridge power dissipation curves. The equation for power dissipation in R1 for a bridge circuit is:

$$P_d = 0.94 \sqrt{\pi R_1 \, V_{PEAK}(I_{OUT})^3}.$$

Several points should be kept in mind when implementing the full bridge:

1) Pins 1 and 3 of the HV-2405E/1205 are no longer at or near GND potential. They "float" up and down at nearly the amplitude of the input waveform. The circuit designer should keep that in mind when considering the safety aspects of his product.
2) The bridge must not be filtered to a pseudo DC. Operation of the HV-2405E/1205 requires that each "zero crossing" get close to zero in order that the device reset for the next cycle. (See scope photo).
3) Care should be taken at the prototyping stage as to how circuit operation is verified. For example, if an oscilloscope is used to monitor input voltage the ground of that scope is normally "floated". The parasitics involved in moving the chassis of the scope to line voltage extremes is likely to cause the "zero crossing" to rise several volts above zero at which point the circuit ceases proper operation. As this effect begins the device will fire on alternate cycles allowing the device to regulate the output but the current peak is back to a high level[1].

Circuits which are self contained should have no problem with the floating ground. Circuits which emit light (LEDs) as the output will be fine as well. If the HV-2405E/1205 circuit using the full bridge must be interfaced with another system with a different ground, opto isolators can be used. For example, a small data acquisition system could be powered from the line using the full bridge and the digital output could be transferred to a PC using opto isolators powered by the PCs power supply.

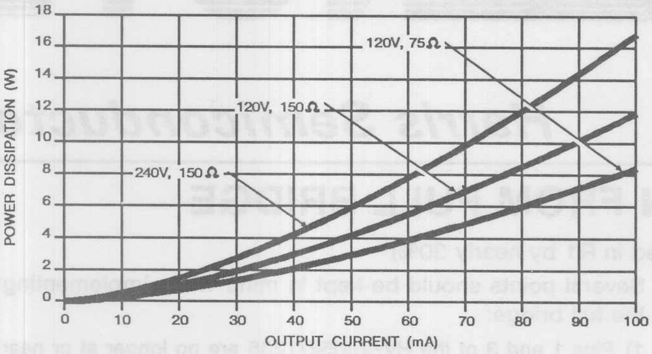
Figure 1 is the standard applications circuit. Figure 2 shows how to implement the bridge circuit using the convenient IC full bridge Harris part number DB1M (approximately $0.29 each in 10,000 piece quantities. Of course the bridge can be built discretely using 4 diodes similar to the 1N4005 (approx. $0.05 each in 10,000 piece quantities).

In summary, in systems where a floating ground can be used, the power dissipated in R1 can be significantly reduced for little additional cost thereby decreasing heat rise in the enclosure and allowing physically smaller components to be used. For 120V applications, switching to the HV-2405E from the HV-1205 to allow a lower resistor value, and taking advantage of the bridge circuit will cut power dissipation in R1 in half! (4.2W for the normal applications circuit compared to 2.1W for the HV-2405E in the bridge circuit).

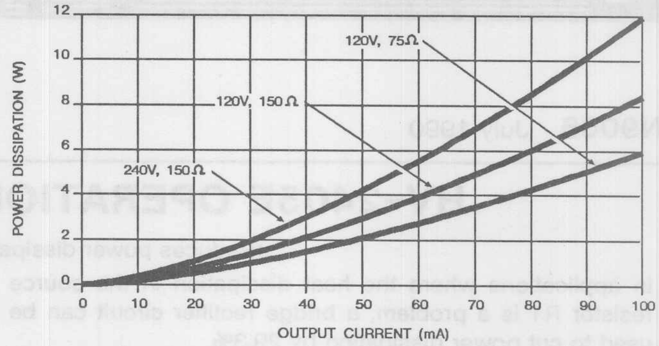
1. See Chapter 4 of GROUNDING AND SHIELDING TECHNIQUES IN INSTRUMENTATION 2nd edition, Ralph Morrison, Wiley-Interscience for explanation of problematic ground loops.

Typical Graphs and Waveforms

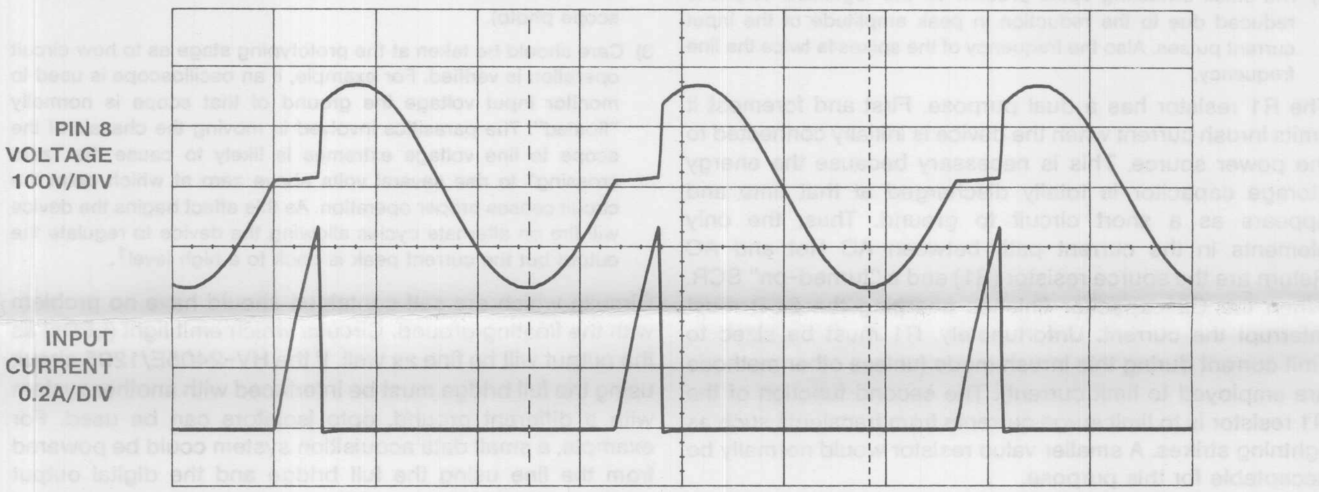
Pd IN R_1 vs. I_{OUT}
BASIC APPLICATIONS CIRCUIT



Pd IN R_1 vs. I_{OUT}
FULL WAVE BRIDGE CIRCUIT



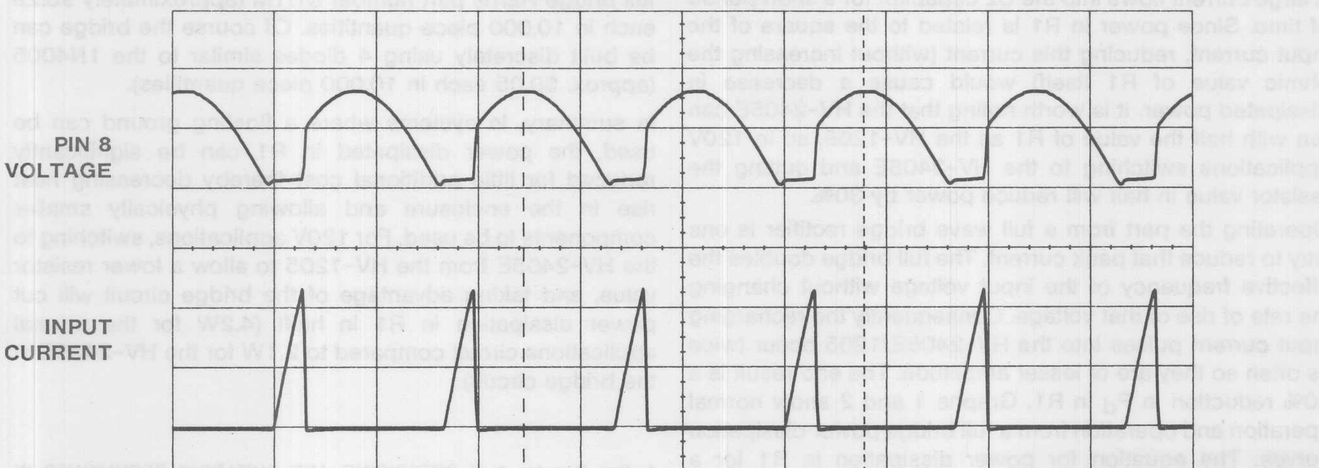
NORMAL OPERATION



Ch. 1 = 100 Volts
Ch. 2 = 0.2 Amps

Time Base = 5.00msec/div
Delta T = 16.7000msec

FULL BRIDGE OPERATION



Ch. 1 = 100 Volts
Ch. 2 = 0.2 Amps

Time Base = 5.00msec/div
Delta T = 16.7000msec

Typical Graphs and Waveforms (Continued)

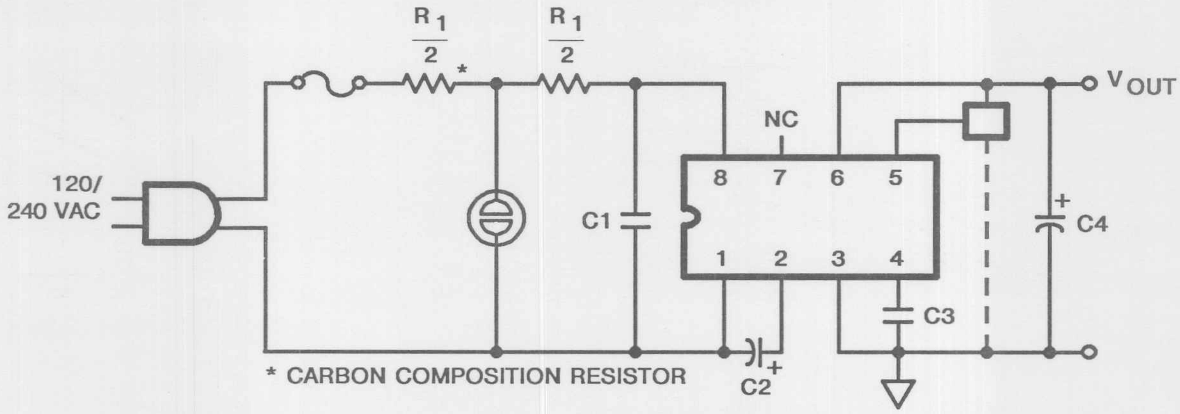


FIGURE 1. BASIC APPLICATIONS CIRCUIT

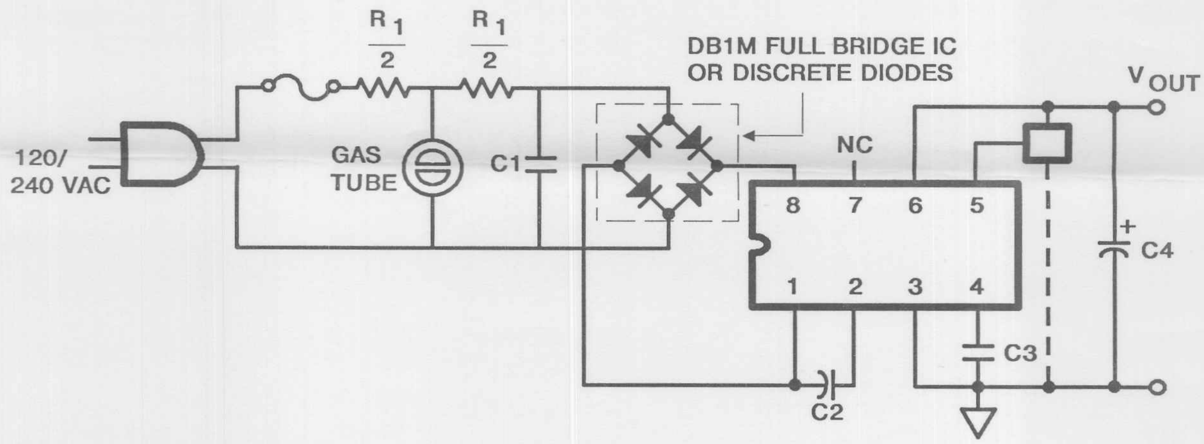


FIGURE 2. FULL BRIDGE CIRCUIT

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